Experimental study of local extinction mechanisms on a spray jet flame

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HIGHLIGHTS

• The extinction mechanisms are studied by high speed OH-PLIF images. A Nd-YAG-laser operating at 532 nm is used to pump a tunable dye laser (Sirah Credo). The camera mounted with an external image intensifier is used at a repetition rate of 10 kHz. The Droplet size and droplet/air velocity are characterised by a commercial PDA system (DANTEC).
• The first extinction mechanism is due to the strong turbulence-chemistry interactions and can be correlated to the behaviour of turbulent velocity field (vortices).
• The second mechanism is related to the droplet-chemistry interactions. The droplets and the vapour surrounding the droplets can extinguish the flame front due to the cooling effect and a too rich mixture in the wake of the drops.

ABSTRACT

This paper presents high-speed (HS) images of OH-PLIF collected at a repetition rate of 10 kHz along the entire length of an \( n \)-heptane spray jet flame. The experimental set-up is composed of an annular non-swirled air co-flow that surrounds a central hollow-cone spray injector, leading to a stable flame with well-defined boundary conditions (Fig.1(a)). The experiments include accurate measurements of droplet size (PDA), droplet and carrier phase velocity (PDA) and two-dimensional flame structure (OH-PLIF). The polydisperse spray distribution yields small droplets along the centerline axis while the majority of the mass is situated as big droplets along the spray borders. The flame structure presents a classical shape, with an inner wrinkled partially premixed flame front and an outer diffusion flame front. Although the High Speed (HS)-OH-PLIF images are only qualitative, they are found to be a sufficient spatial and temporal resolution to relay the dynamics of extinctions events. Applying data processing tools and coupling with aerodynamics results allowed to highlight different extinctions mechanisms. In the inner reaction zone, the measured speed, as well as the turbulent kinetic energy, showed that the large turbulence scales played a significant role in the dynamics of extinction (Fig.1(b)). However, the locally extinction in the outer reaction zone can be attributed to the big droplets that present a skin term for the flame (Fig.1(c)).

Fig 1: (a) Experimental setup. (b) Extinction in inner reaction zone. (c) Extinction in the outer reaction zone